6th Annual NASA Earth Science Technology Conference

Reconfigurable Protocol Sensing in an End-to-End Demonstration

(This work is funded under Advanced Information Systems Technology (AIST) NRA-02-OES-04)

College Park, MD

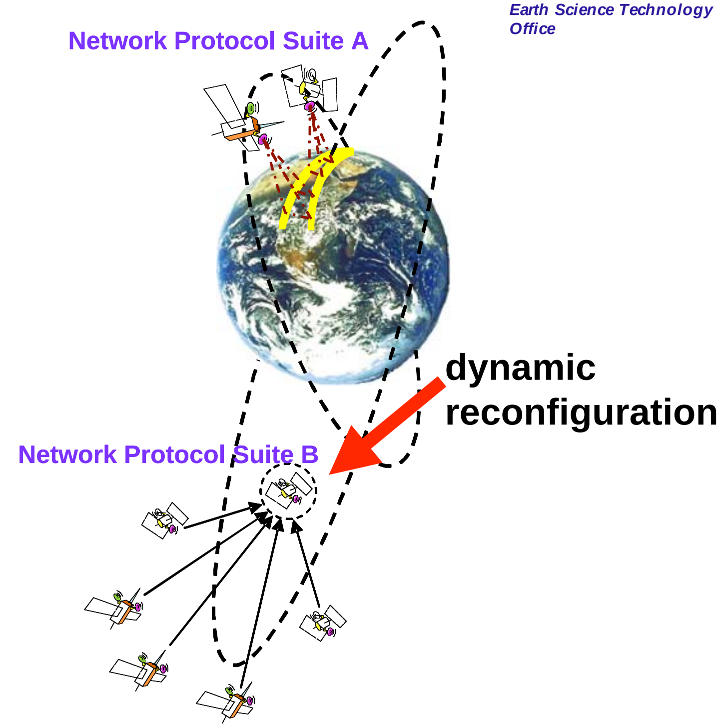
June 28, 2006

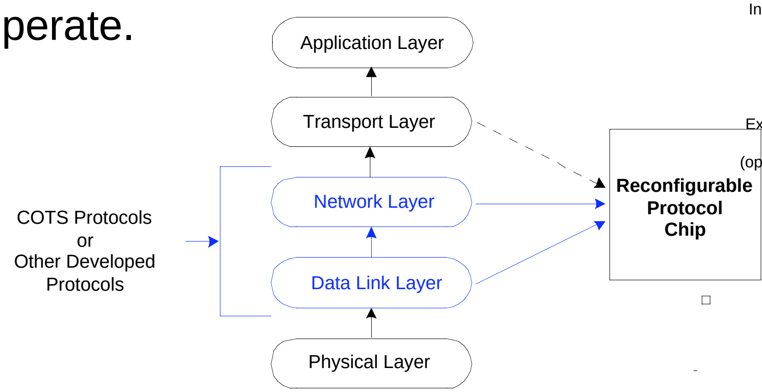
A. Gray, C. Okino, J. Schoolcraft, R. Mukai,
P Arabshahi, S. Darden, C. Lee
Jet Propulsion Laboratory

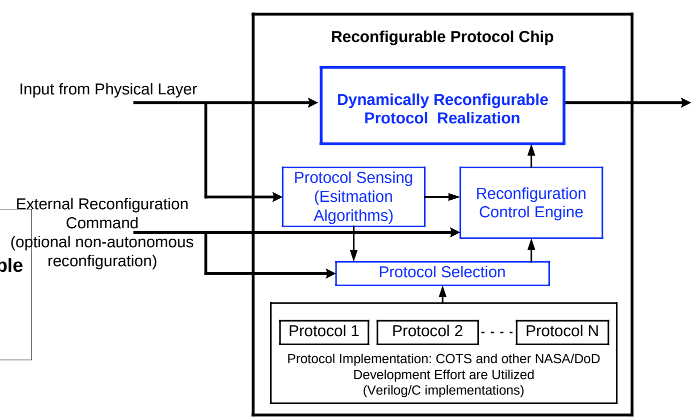
C. Brambora, C. Deleon, D. Fisher, W. Fong, D. Israel, J. Soloff
NASA GSFC

INTRODUCTION

- Problem: Varying mission, directorate, and platform objectives and costs result in a heterogeneous space-based communication environment.
  - Over specifying a single protocol to provide interoperability will over constrain a mission approach
  - Ultimately, there will be a variety of communication platforms with varying network protocols
- Focus of this work is on link layer approaches.
  - Autonomously sensing a new network and reconfiguring the link layer format to interoperate.





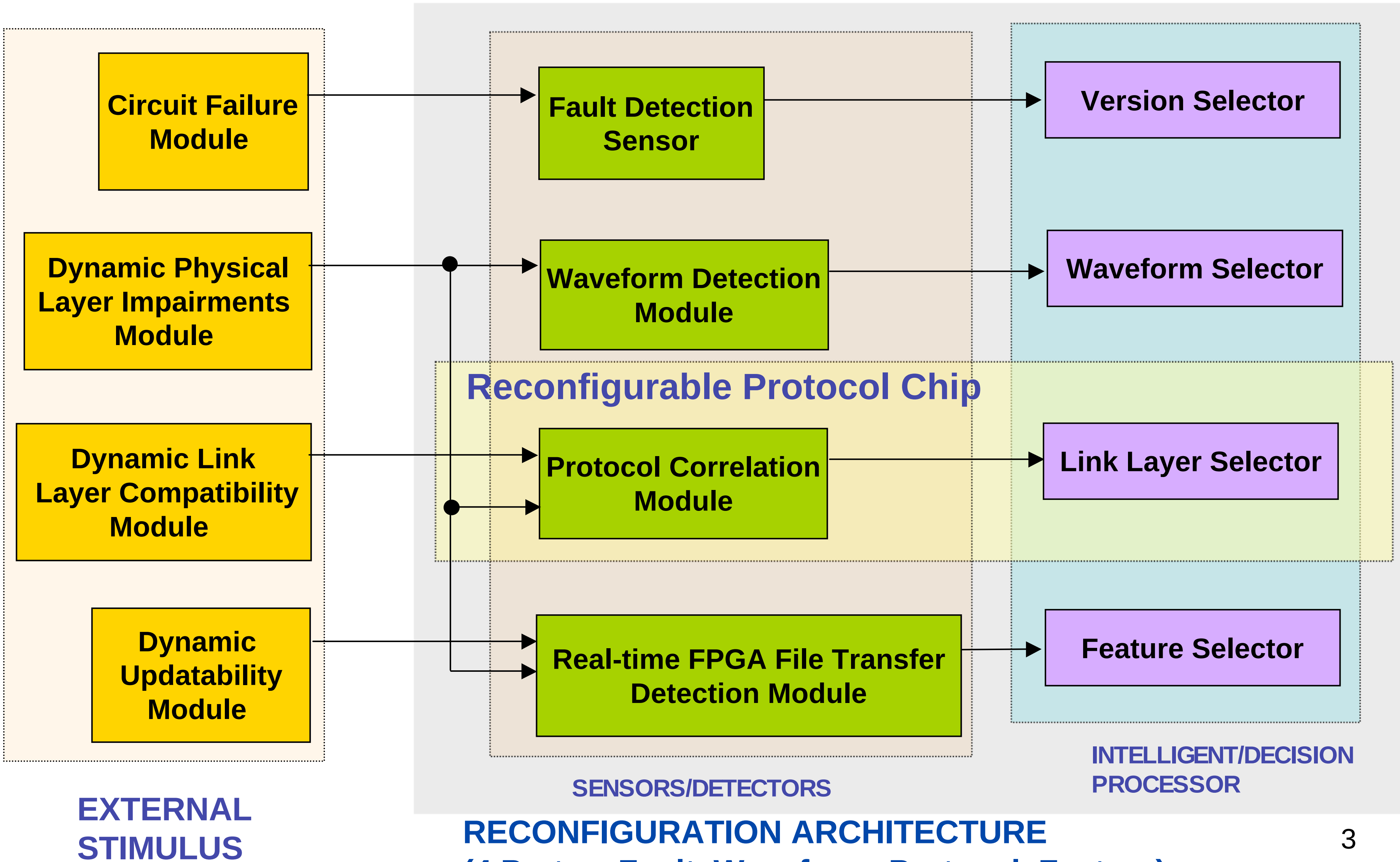


Developed a framework for a reconfiguration platform

ESTO

Earth Science Technology Office

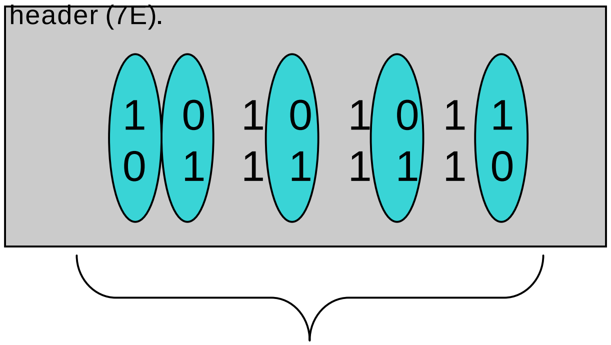
Stimulus & Space-based Reconfiguration Architecture



RECONFIGURATION ARCHITECTURE
(4 Parts – Fault, Waveform, Protocol, Feature)

- **Link Layer Recognition and Processing Schemes**
  - Consider the two common link layer framing formats: RFC 1662 (HDLC) and 802.3
  - Generic Framing Procedure (GFP) is a common framing approach that is capable of carrying various traffic types across a SONET/SDH network or Optical Transport Network (OTN)
    - Based on ITU-T Recommendation G.7041/Y.1303 where interfaces for G.709 is specified for OTN

Use standard majority rule to decide between 802.3 header (AB hex) and HDLC header (7E).



Identify unique bits between two link layer formats

Preamble 56-bits	Start Frame 8–bits (AB)	Destination Address 48-bits	Source Address 48-bits	Length 16 -bits	LLC	Data 46 – 1500 bytes	Pad	FCS 32 bits

802.3

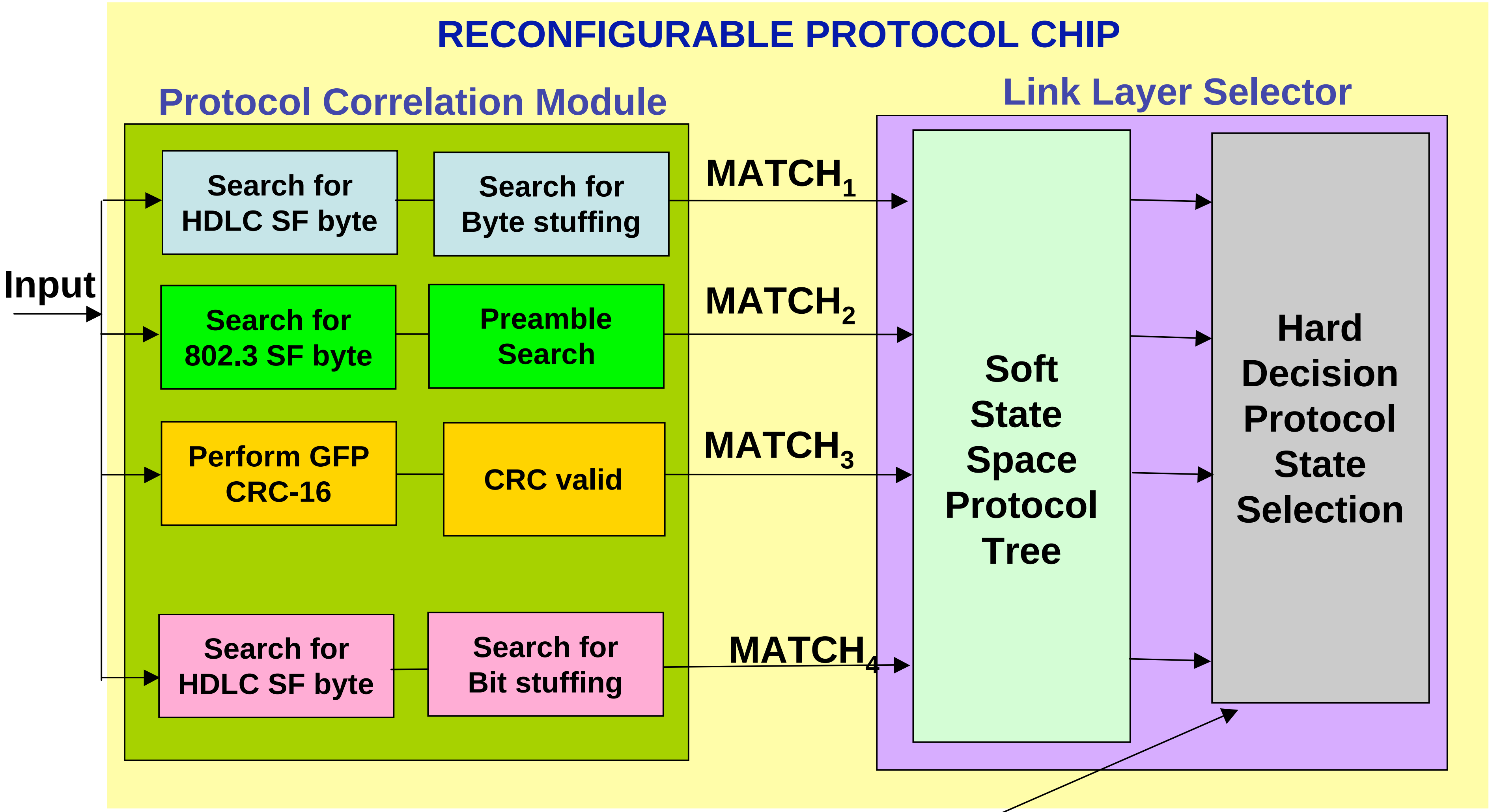
Opening Flag 8 –bits (7E)	Address Field 8 or 16-bits	Control 8 -bits	Data 8*N -bits	CRC 16 -bits	Stop Flag 8 –bits (7E)

RFC 1662 (HDLC)

Core Header		Payload	Payload FCS
PDU Length Indicator	Core Header Error Control (HEC) Field	4 to 65535 octets	Payload Frame Check Sequence
2-octets	2-octets		4-octets

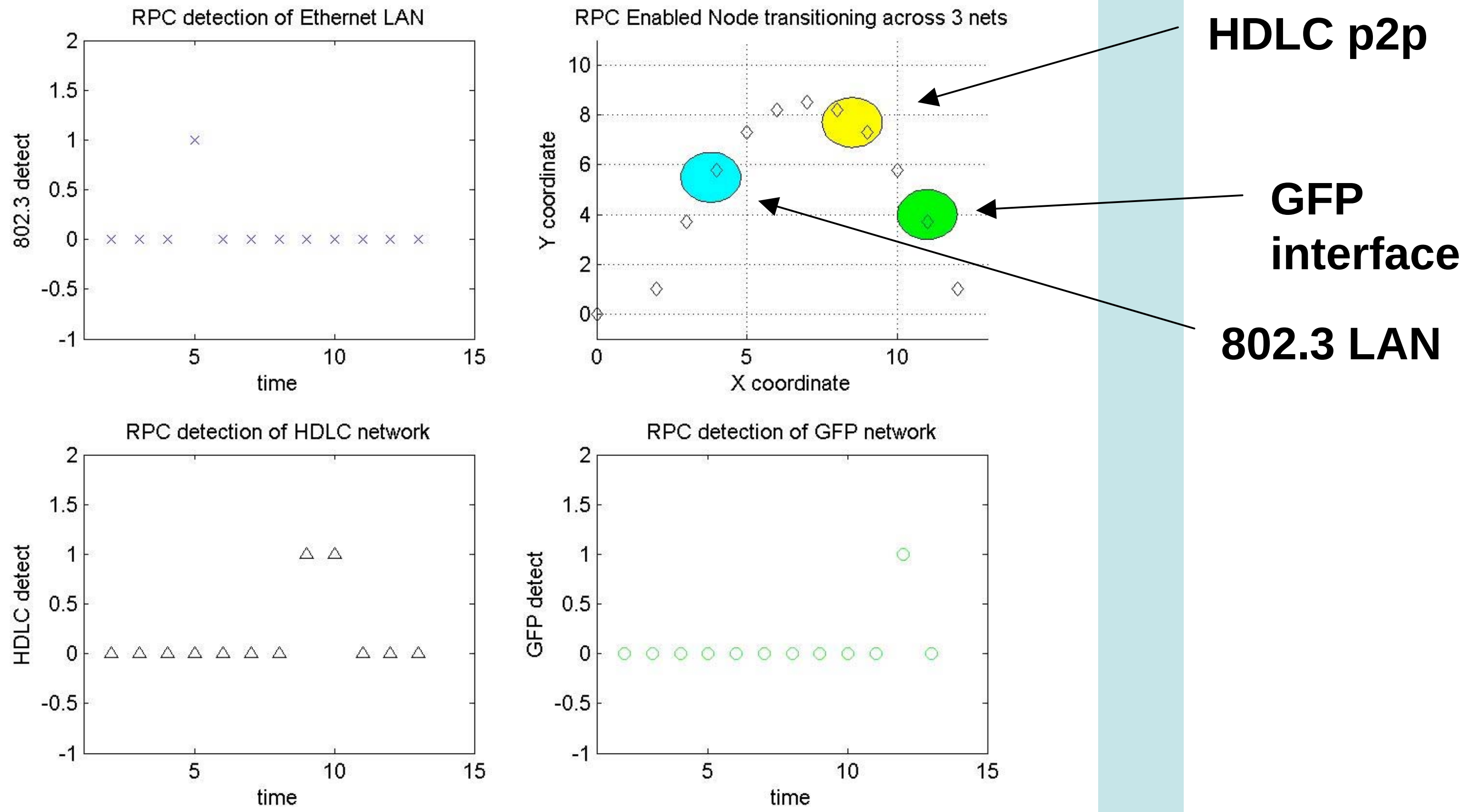
GFP

- *RFC1662 (HDLC), 802.3, and GFP*

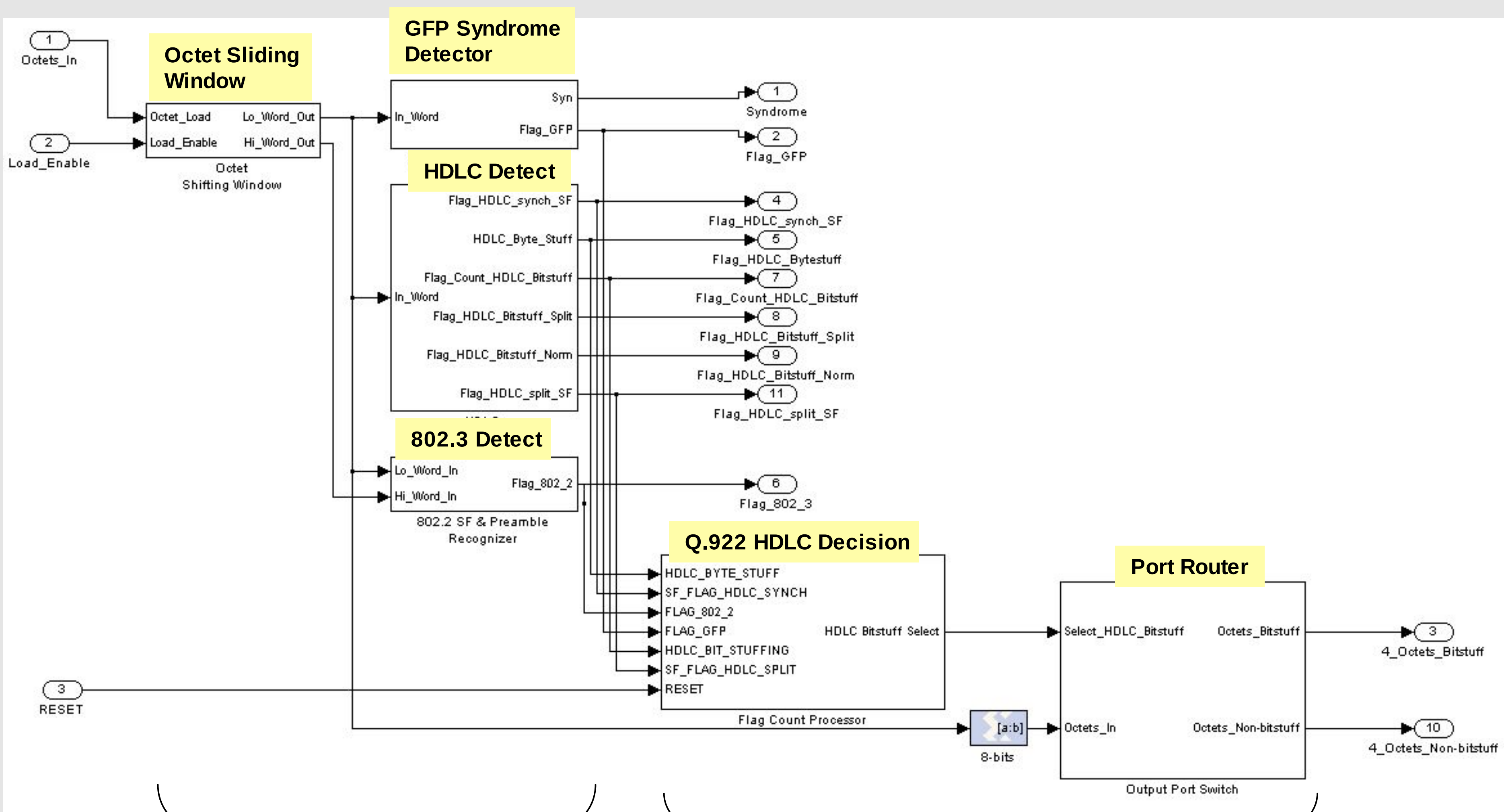


Selectable Internal Automated selection or processor output decisions

Notional Operational Use Case for RPC



Protocol Sensing Module



Protocol Correlator

Link Layer Selector

- UPDATED Analysis of Sensing with Added Byte Stuffing (clean signal)

Transmitted Protocol: GFP	
Sensing Protocol:	Percentage Flags Detected
GFP	**0.11%**
802.2	**0.00%**
HDLC framing ONLY	5.76%
HDLC byte-stuffed	**0.01%**
HDLC bit-stuffed	**5.41%**
Transmitted Protocol: 802.2	
Sensing Protocol:	Percentage Flags Detected
GFP	**0.03%**
802.2	**26.60%**
HDLC framing ONLY	4.42%
HDLC byte-stuffed	**0.00%**
HDLC bit-stuffed	**3.04%**
Transmitted Protocol: HDLC (bytestuffed)	
Sensing Protocol:	Percentage Flags Detected
GFP	**0.02%**
802.2	**0.00%**
HDLC framing ONLY	32.47%
HDLC byte-stuffed	**3.01%**
HDLC bit-stuffed	**18.91%**
Transmitted Protocol: HDLC (bitstuffed)	
Sensing Protocol:	Percentage Flags Detected
GFP	**0.00%**
802.2	**0.00%**
HDLC framing ONLY	2.88%
HDLC byte-stuffed	**0.00%**
[illegible]	[illegible]

For GFP we perform a relative percentage hit count selection

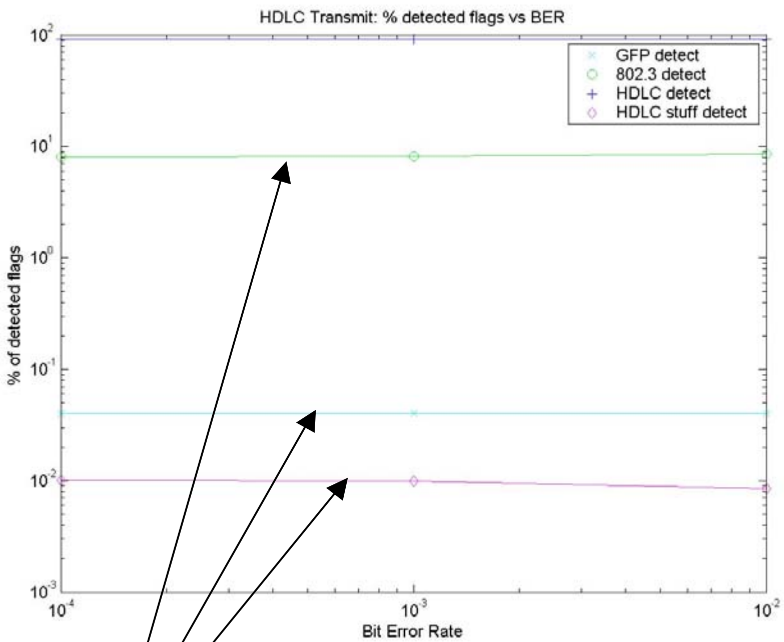
Upper bound is 64K bytes if maximum length GFP packets

Use "default" circuit to process most likely framing protocol while detecting for GFP or if hit ratios are sufficiently high for other

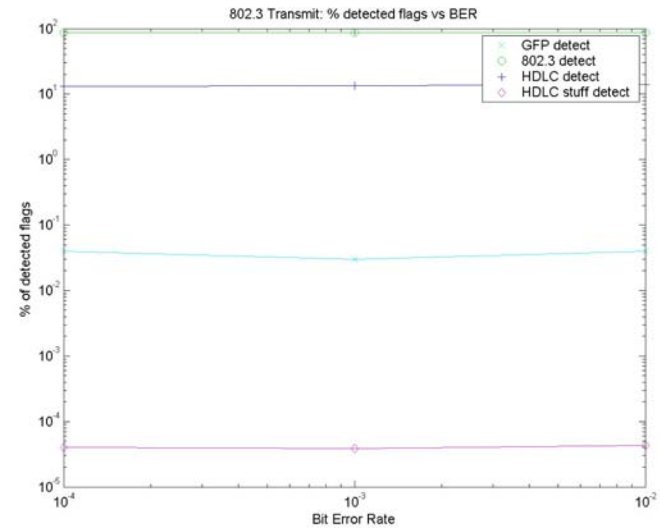
In general 3K bytes are sufficient.

- % flag detection versus bit error rate

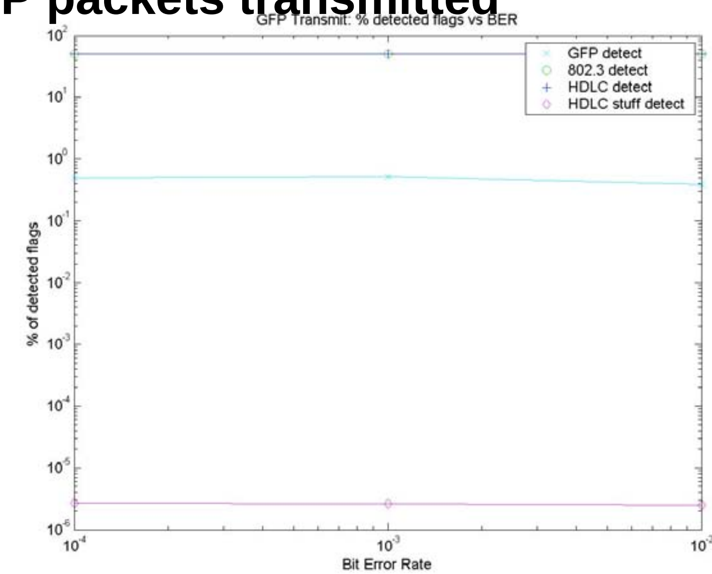
HDLC packets transmitted



802.3 packets transmitted



GFP packets transmitted



% of Flags detected <u>invariant</u> with respect to Bit Error Rate (for all 3 protocols)

APPLICATIONS:
Coordinated with GSFC on GRID

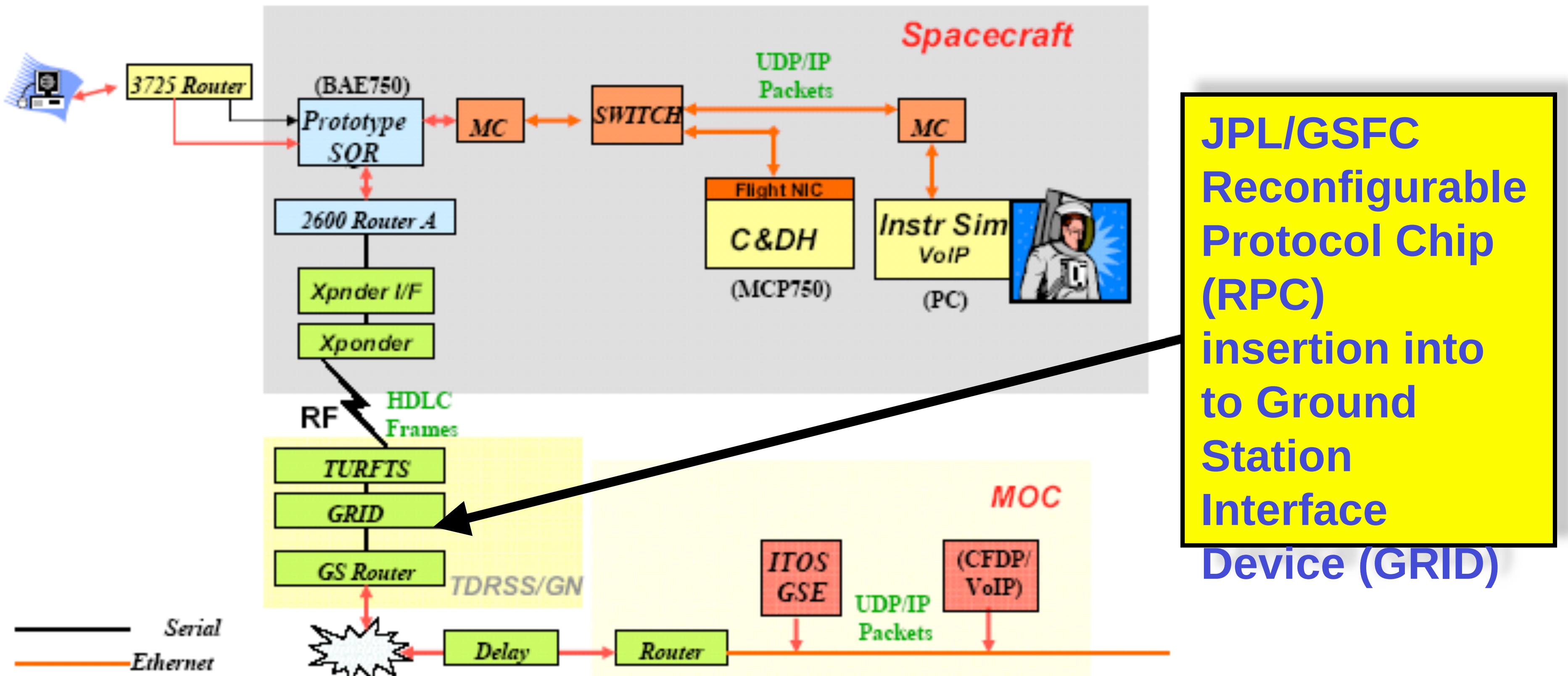
ESTO

Earth Science Technology Office

- Dave Israel, Jane Marquart, Greg Menke (GSFC) End-to-End IP Demonstration with infusion plan from RPC (JPL/GSFC collaboration)

Goddard Space Flight Center

Overview



• **Original artwork from slides titled "GSFC Technology End to End IP Demonstration" by D. Israel, J. Marquart, G. Menke, April 2005.**

APPLICATION:
RPC - GRID Demonstration

ESTO

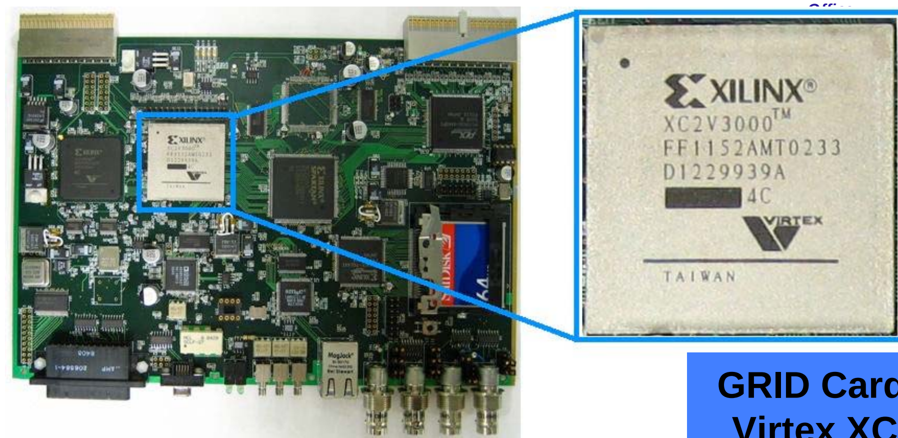
Earth Science Technology Office

1. **RPC technology was integrated into the GRID card (collaborated with Chris Deleon at GSFC)**

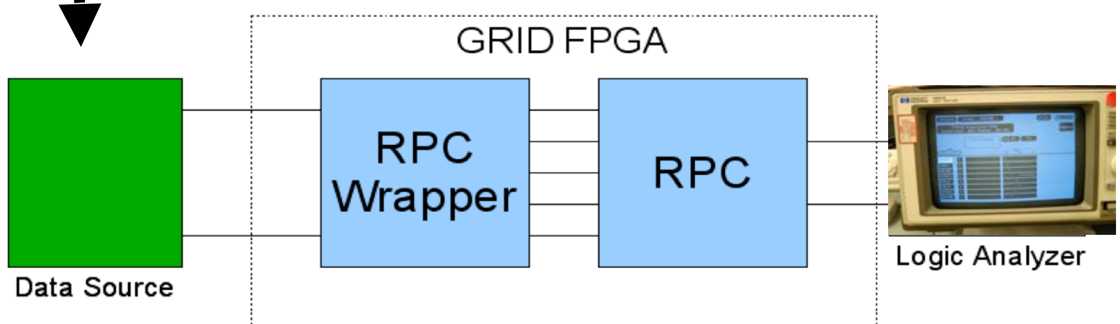
- Cisco 2516 Router

2. **CISCO Router connected and successful recognition of HDLC format performed and data routed to appropria port**
3. **Test equipment connected to verify differing bit pattern routed data to alternate port**

- General Data Products 615 Data Test Set



GRID Card FPGA: Virtex XC2V3000



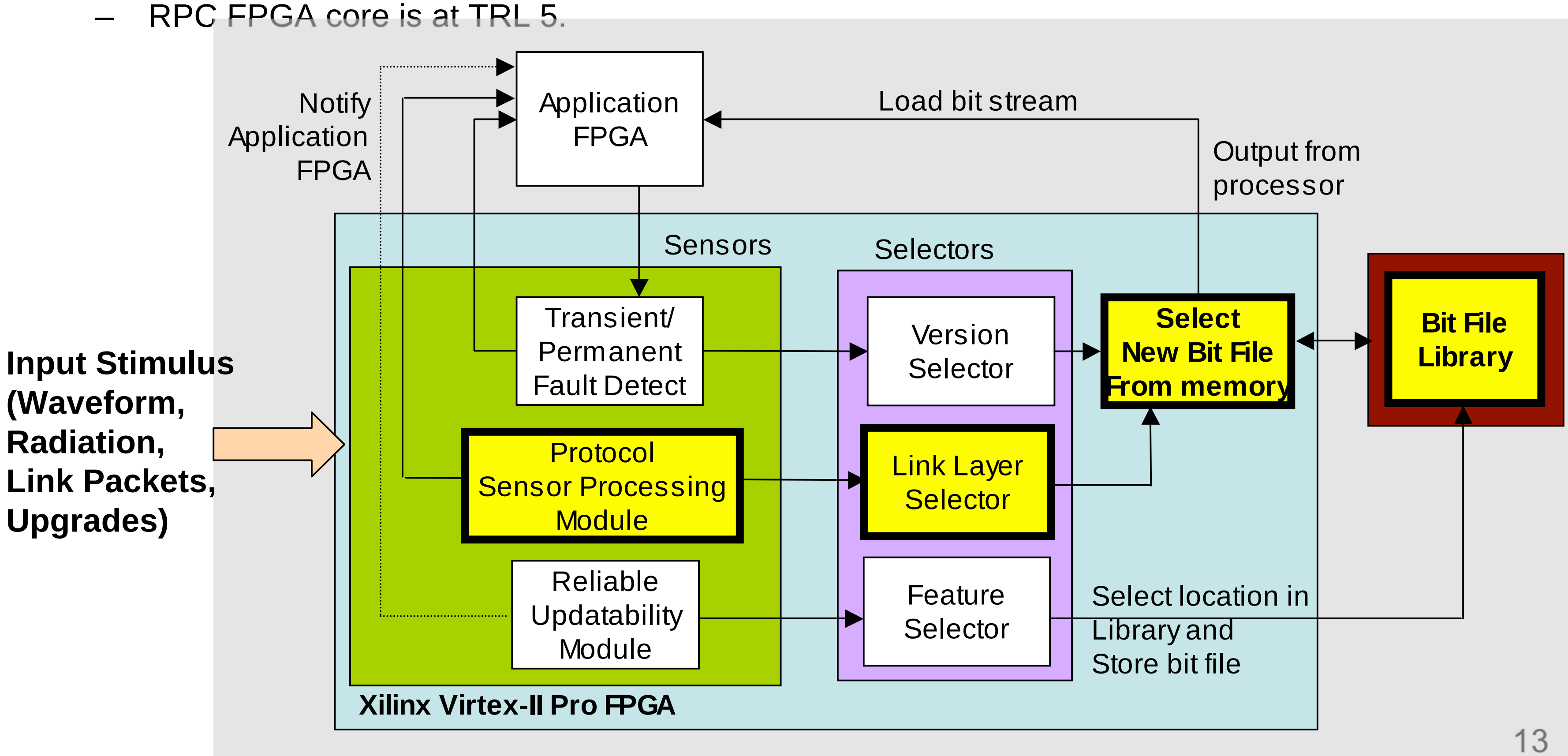
- **HDLC Bitstuff idle pattern – 0x7E (Cisco 2516)**
  - **RPC "snaps" to HDLC bitstuff setting when not set to default to it**
  - **"Keep alive" bursts between idle pattern do not affect protocol lock**
- **Other data patterns (arbitrary via GDP 615)**
  - **RPC falls back to default configuration setting when stream fails to match protocol correlation**

- Benefits and possible shortcomings of the RPC
  - PROS:
    - Allows for a highly flexible approach to networking on a per mission basis
    - Allows for spacecraft to communicate with heterogeneous resources within its own network domain
    - Allows for interoperability between space elements across multiple missions/multiple network domains
    - RPC might be the solution to ESMD Constellation diverse needs in terms of link layer functional requirements (e.g. the diverse needs of a DTE versus a proximity link)
  - CONS
    - Core will need to integrated into the spacecraft radio
    - As networks transition, core will need to be upgraded (although over-the-air upgradability is feasible)
    - Coordination within communities such as the Space Communications Architecture Working Group (SCAWG), and possibly standards such as CCSDS to help in the adoption process (i.e. a standard for reconfiguration)

SUMMARY

- Accomplishment Highlights
  - Developed a framework for a reconfiguration platform
  - Developed and analyzed the performance of a layer 2 protocol sensing function.
  - Developed a FPGA core called the RPC that has been infused into the GRID and in plans for integration into the Electra platform

- TRL Assessment
  - RPC FPGA core is at TRL 5.



Space-based Reconfiguration HW Architecture